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(54) Title: CONDUCTIVE INK

(57) Abstract

The invention relates to a conductive ink material comprising a vehicle/binder system containing a metallic pigment; the inventive conductive ink material applicable in small application filmweights but presenting a high conductivity and showing a fast drying speed is characterized in that the vehicle/binder system is a water base binder system having an application viscosity of less than 1000 cps (mPa.s) preferably of less than 500 cps (mPa.s) and that the pigment is a precious metal pigment or comprises at least a precious metal coating.

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Conductive ink

The invention relates to a conductive ink material comprising a vehicle/binder system containing a metallic pigment.

Known conductive ink materials or coatings are based on silver flakes as a metallic conductive pigment incorporated into a high viscosity vehicle/binder system having a formulation viscosity of about 10000 to 12000 cps (10000 - 12000 mPa.s). Such binder systems for example are based on vinyl or acrylic resins dissolved in organic solvents which dry by evaporation. Other known binder systems for example are based on epoxy or polyester acrylate systems comprised of 100 % of solids, which systems dry by UV-radiation curing.

However applying known conductive inks with the above viscosity to a substrate material requires high application filmweights in order to achieve a desired conductivity property. This is caused by the fact that due to the high viscosity of known vehicle/binder systems leafing of conductive pigment flakes is impeded thereby requiring a higher amount of conductive pigment.

In order to dry or cure high filmweight surface coatings more energy is needed and also a long exposure to heat and/or UV-radiation is required.

The coating or printing procedures using screen printing processes (flatbed or rotary), both of which use high application filmweights, are relatively slow compared to conventional liquid ink processes because of the length of time the ink must remain exposed to drying units. There is however the possibility to use reel to reel screen presses with multi oven/UV driers which increase running speed but are still slow compared to liquid ink processes, i.e. flexo or gravure printing processes.

It is therefore an object of the present invention to propose a conductive ink material applicable in small application filmweights but presenting a high conductivity and showing a fast drying speed.

A conductive ink material according to the invention is characterized in that the vehicle/binder system is a water base binder system having an application viscosity of less than 1000 cps (mPa.s) preferably of less than 500 most preferably of less than 300 cps (mPa.s) and that the pigment is a precious metal pigment or comprises at least a precious metal coating. A water base binder system has a much lower application viscosity than the binder systems used with known conductive ink materials thereby promoting leafing of the metallic pigment resulting in greater alignment of conductive pigment at the surface of an ink film applied to a substrate material. Since metallic pigment flakes can orientate themselves parallel to the surface in a compact interlocking position conductivity of

the ink film is considerably increased. The use of precious metal pigment additionally increases the conductivity of the ink film.

Within the scope of the invention there are also conductive ink materials having a formulation viscosity of more than 1000 cps prior to printing which by adding water can be decreased to fall within the above application viscosity range.

The conductive pigment's more random orientation throughout the ink film necessitates a higher film thickness when a known high viscosity vehicle/binder system is used. The more random orientation in these known types of ink are caused first of all by the high viscosity impeding movability and thus leafing of the metallic pigment. The lower surface tensions of the above mentioned organic solvents reduce the ability of the conductive pigment to align and orientate at the surface. The higher film thickness required in connection with known conductive ink materials means a larger distance for the conductive pigment to travel or to leaf to the surface which also results in bad surface orientation and a low conductivity.

The conductive ink material according to the invention not only presents a much lower application viscosity but additionally a higher surface tension due to the highly polar bonds of the water base binder system therewith promoting alignment of metallic pigment at the surface resulting in high conductivity. Accordingly lower application filmweights are needed to obtain a desired conductivity. Thus running speeds of coating or printing procedures are increased since the time an ink film must remain exposed to drying units is reduced. Use of the

conductive ink material according to the invention also allows to use liquid ink processes such as flexo or gravure printing processes and other low filmweight coating processes. Accordingly it is now e.g. possible to use a conductive ink printed on a plastic film as part of a mechanism that acts as a voltage or charge tester which currently is required in connection with batteries. Also the packaging for batteries can be printed by gravure process because of the high conductivity efficiency and fast drying speed of conductive ink material. But also in the security and electrical circuit industry liquid ink printing processes should present an advantageous alternative to electrically depositing metals on substrate materials since electro-deposition is extremely expensive and much slower compared with highspeed printing processes.

A prefered water base binder system contains about 20 to 50% preferably 30 to 40 % per weight of a solid binder substance and a viscosity of preferably less than 300 cps (mPa.s), most preferably 20 to 200 cps (mPa.s). Preferably a water base colloidal dispersion of aliphatic polyester and/or polyurethane is used. A water base colloidal dispersion of an aliphatic polyester-polyurethane is obtainable as ALBERDINGK V_j - U 610 W from ALBERDINGK BOLEY GMBH, Uerdingen, Germany, the type of dispersion being anionic and having about 9.5 % per weight of N-Methyl-2-pyrrolidon. However other aliphatic urethanes, acrylics or water base polymers can be used depending on the substrate to be printed or coated. As an example for an acrylic binder system Zinpol 146 available from ZINCHEM, INC.,Sommerset, N.J, USA, should be noted comprising about 35 % per weight of an acrylic resin and about 61.8 % per weight of water and additionally 3.2 % per weight of dimethylethanolamine.

Although the shape of the metallic pigment particles is not restrained to one predetermined profile, it is preferred to use metallic flakes in order to promote interlocking surface orientation. Mostly preferred, however, are "Lamella" shaped metallic flake pigments, which preferably are silver flakes. However, silver coated copper or other precious metals giving similar conductive properties can also be used. The precious metal pigment preferably has been treated with fatty acids, or compounds of fatty acids like fatty alcohols, preferably with stearic acid. However, palmitic acid should also be suited. The flakes have preferably low particle size compared with known conductive ink materials which has been determined according to the Cilas-method:

d_{10}	0.5 - 3.5	microns
d_{50}	1.0 - 10.5	microns
d_{90}	6.0 - 21.0	microns

That means about 10% of the metallic pigment have a particle size of less than 3.5 microns, 50% of the metallic pigment has a particle size of less than 10.5 microns and 90% of the metallic pigment has a particle size of less than 21.0 microns.

Mostly preferred the particle size is:

d_{10}	0.5 - 1.0	microns
d_{50}	1.0 - 3.5	microns
d_{90}	6.5 - 10.0	microns

The low particle size has been found to considerably improve the conductive properties of the ink film.

Adding a modified hydrocarbon surfactant composition available from Rit-Chem Co., Inc. of Pleasantville, N.Y., USA, under the tradename ZEROFOME NS-31F into the water base vehicle/binder system reduces or prevents foam generation when preparing the ink material.

In order to incorporate a high percentage of silver flake pigment into a low viscosity binder system it is preferred to add a wetting agent to the conductive ink material. A preferred formulation of the conductive ink material according to the invention comprises 2,4,7,9-tetramethyl-5decyn-4,7-diol (75% in ethylene glycol) (available as Surfynol 104 H) and/or modified nonylphenoxypoly(etyleneoxy)ethanol which is available from RHONE-POULENC, Cranbury, New Jersey, USA, under the domestic tradename IGEPAL CTA 639 W SURFACTANT and under the export tradename ANTAROX CTA-639 W SURFACTANT as a wetting agent.

A preferred formulation of the inventive conductive ink material comprises 15 to 45 % per weight of a water base binder system, 0.0 to 6.5 % per weight of a wetting agent, 20 to 80 % per weight of a metallic pigment and 0 to 20 % per weight of water. The conductive ink material preferably comprises 0.1 to 3.5 % per weight of 2,4,7,9-tetramethyl-5decyn-4,7-diol (75 % in ethylene glycol). Another preferable formulation of the conductive ink material comprises 0.1 to 3.0 % per weight of modified nonylphenoxypoly(ethyleneoxy)ethanol.

However, a mostly preferred formulation of the conductive ink according to the invention is characterized by:
- 31.7 % of a water base colloidal dispersion of aliphatic polyester/polyurethane

- 0.5 % of a modified hydrocarbon surfactant composition

- 57 % silver flake (silver 95 %, stearic acid 5%, e.g. "Alcan Silver Flake 750")

- 0.7 % 2,4,7,9-tetramethyl-5decyn-4,7-diol (75% in ethylene glycol)

- 1.8 % of modified nonylphenoxypoly(ethyleneoxy)ethanol

- 8.3 % water

Another preferred formulation comprises as water base vehicle binder system the dispersion Zinpol 146 or U 610 W which have already been identified.

A method for preparing conductive ink according to the invention consists in separately preparing a vehicle component and a pasteous component comprising the metallic pigment. Firstly the vehicle component is weighed into a suitable vessel for water base ink coating manufacture. A cavitational head type mixer is then preferably used to mix the defoamer, which preferably is 2,4,7,9 tetramethyl-5decyn-4,7-diol (75 % in ethylene glycol), which is added to the vehicle component while mixing slowly.

In a separate vessel a wetting aid, preferably modified nonylphenoxypoly(ethyleneoxy)ethanol is blended with the water component according to the above given formulation to form a gel. This is preferably done on the similar mixing equipment. Also modified nonylphenoxypoly(ethyleneoxy)ethanol is added.

The gel so obtained is then added to the conductive pigment, which is pre-weighed in a drum of suitable size. The gel comprised of wetting aids and water is poured on top of the pigment and the drum is sealed. The volume of pigment and gel should occupy 50 - 75 % of the drum. The drum is then rotated on a drum roller for about 20 minutes or until the substance forms a homogenous paste.

The paste containing the metallic pigment is then added to the original vessel containing the vehicle component while agitating slowly preferably using the cavitational head type mixer. To prevent air entrapment once the paste has been added a vacuum sealed vessel may be used.

Claims

1. Conductive ink material comprising a vehicle/binder system containing a metallic pigment, characterized in that the vehicle/binder system is a water base binder system having an application viscosity of less than 1000 cps (mPa.s) preferably of less than 500 cps (mPa.s) and that the pigment is a precious metal pigment or comprises at least a precious metal coating.

2. Conductive ink material according to claim 1, characterized by a water base binder system comprising 30 to 40 % solids.

3. Conductive ink material according to claim 1 or 2, characterized by a water base colloidal dispersion of an aliphatic polyester/polyurethane.

4. Conductive ink material according to anyone of the preceeding claims, characterized by

a water base binder system comprising acrylics or other polymers.

5. Conductive ink material according to anyone of the preceeding claims,
c h a r a c t e r i z e d i n t h a t
the metallic pigment comprises metallic flakes treated with fatty acid, or fatty acid components like fatty alcohols, preferably with stearic acid.

6. Conductive ink material according to anyone of the preceeding claims,
c h a r a c t e r i z e d i n t h a t
the size of the metallic pigment flakes according to the Cilas-method is determined by

d_{10}	0.5 - 3.5 microns
d_{50}	1.0 - 10.5 microns
d_{90}	6.0 - 21.0 microns

preferably by

d_{10}	0.5 - 1.0 microns
d_{50}	1.0 - 3.5 microns
d_{90}	6.5 - 10.0 microns

7. Conductive ink material according to anyone of the preceeding claims, additionally comprising a modified hydrocarbon surfactant composition.

8. Conductive ink material according to anyone of the preceeding claims, additionally comprising a wetting agent which preferably contains 2,4,7,9-tetramethyl-5decyn-4,7-diol (75% in ethylene glycol) and/or a modified nonylphenoxypoly(ethyleneoxy)ethanol.

9. Conductive ink material according to anyone of the preceeding claims comprising:
15 to 45 % per weight of a water base binder system,
0.0 to 6.5 % per weight of a wetting agent
20 to 80 % per weight of a metallic pigment
0 to 20 % per weight of water

10. Conductive ink material according to claim 7, 8 or 9, comprising
0.1 to 3.0 % per weight modified nonylphenoxypoly(ethyleneoxy)ethanol.

INTERNATIONAL SEARCH REPORT

Inter al Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C09D11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C09D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 230 303 (B.F. GOODRICH) 29 July 1987 see page 3, line 4 - page 5, line 51; claims 1,5,13	1
A	EP,A,0 462 720 (FORD) 27 December 1991 see page 3, line 31 - page 4, line 9; claim 1	1
A	FR,A,2 508 922 (RCA) 7 January 1983 see page 2, line 20 - page 5, line 2; claims 1,6; examples	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Information on patent family members

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